Mathematical News that's Fit to Print

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The theme of this session – understanding new trends, new results - invites reflection on two small Anglo-Saxon words: "new" and "news." "New" has several distinct meanings: not existing before; not known before; fresh; different; not old; of recent origin. "News" refers to tidings - to information about recent events.

The two words, in our context, reflect two professions: mathematician and journalist. Mathematicians deal with the new; journalists with news. Despite the common etymology of these words, in practice they have almost opposite meanings to the mathematician and the journalist. To understand new trends and new results, we have to examine how mathematicians and journalists differ in their perceptions of what's new and of what's news.

1. NEW MATHEMATICS

What is new to the mathematician? For some it is theorems - proofs of old conjectures or discoveries of new results. In 1983 it was Gerd Faltings' proof of the Mordell conjecture; in 1985 it was Louis De Branges' proof of the Bieberbach conjecture. In 1988 it was, for a short time, Yoichi Miyaoka's claim that he had proved Fermat's Last Theorem.

For others, what is new in mathematics are trends in research. For a good part of the 1970's, catastrophe theory was new; now attention has shifted to fractals and chaos. Forty years ago, many new trends in mathematics were expressed in the collective work of Nicholas Bourbaki as the culmination of

David Hilbert's agenda to provide a complete logical portrait of known mathematical theory. In the past quarter century, mathematics shifted once again to a counterpoint with applications - to nonlinear analysis and computational geometry, to spatial statistics and cryptography. Applications have spread from biology to finance, from fluids (flames, fusion, tornadoes) to data (stock markets, satellite transmissions, geological sensors).

Still for others, the frontier of mathematics is defined by new concepts or by syntheses of old concepts into significant new perspectives. Although algorithmic notions are not new, in 1971 when Stephen Cook wrote his seminal paper on complexity theory, the concept of NP-complete was brand new to mathematics. Although neither iteration nor dynamical systems are new - the former having deep roots in Newton's method, the latter in the work of Poincaré - the derivative concept of deterministic chaos is essentially new and potentially revolutionary. Although modelling and simulation are not new, the idea of computational science as a third paradigm paralleling experimental and theoretical methodology is new to the world of mathematics and science.

2. MATHEMATICAL NEWS

The journalist, in contrast, deals with news, which in this commercial age is not just a record - as the *New York Times* says - of all that's fit to print, but really a record of all that the public (or advertisers) are willing to purchase. What gets printed, by and large, is what interests the public.

There are, of course, many different publics reached by as many different media. What is of interest to one may be almost irrelevant to another. Magazines, newspapers, museums, radio, television, film, and books are all aspects of a vast and diverse media world. As mathematicians differ in their interpretation of the new, so journalists will differ in their view of news.

Serious intellectual magazines such as *Science* or *Nature* and newspapers such as the *New York Times*, *Le Mond*, or the *Guardian* do cover advances in mathematics - not often or regularly, but enough to meet a minimal professional obligation in which their editors believe. That they don't provide more coverage is largely due to limitations on audience interest, or to editor's perceptions of audience interest. Their readers want a potpourri of news, not too much of any one thing.

Most newspapers and magazines do not feel any obligation to cover mathematics (or even science) regularly. For them, mathematics is not a regular news beat the way health, politics and sports are. The difference is not because there is less news in mathematics, or less significant news, but because there is less interest among the readers. It is the readers, not the mathematicians or the journalists, who ultimately decide what news is fit to print.

Printed media do not, of course, reach the public at large. At best, they reach and influence public leaders. To reach a mass audience, one must use the media of the masses - primarily television. In a mass media the costs are higher and the common denominator of audience interest is lower. Together, these constraints virtually squeeze mathematics out of the picture. In the United States at least - where admittedly the common public intellectual level is not as high as in some other countries - I cannot ever recall seeing strictly mathematical news on either a commercial or public television news show.

I can summarize these reflections by a sweeping generalization: what the mathematician considers new, the journalist does not consider fit to print. There are exceptions, of course, but by any reasonable standard of measurement applied to the planet's five billion inhabitants, these exceptions amount to a set of measure zero, or at most epsilon.

3. CASE STUDY

Rather than continuing to dwell in generalities and abstractions, I think it might be helpful to examine these issues in terms of a case study with which

I am familiar - the effort by the mathematical community in the United States to increase media coverage of mathematics. Our experience, with its share of successes and failures, illustrates most of the concerns that would face any country embarking on a similar venture. It also highlights intellectually interesting issues of what should be covered, what actually is covered, and how that coverage is interpreted.

Before beginning I should say that this recital of events is not by any respectable standard an objective report. I have been in the middle of many of these events, sometimes as a quasi-journalist, sometimes as an advisor, and occasionally as the responsible decision-maker. One of the responsibilities of an alert audience is to detect bias and filter it out.

I'll begin the story at the point where I know it best - in the early 1970's - although the real roots go back to events following the end of the Second World War. In the 1970's, Saunders Mac Lane was very active in political leadership of the American mathematical community. He was one of the very few persons who had been president of both the American Mathematical Society and the Mathematical Association of America, and he was a member of the governing board of the U.S. National Science Foundation, the government agency that awards grants for research and education in science, mathematics, and engineering. For a period of time he also served as Vice President of the National Academy of Sciences, a private self-governing organization chartered by the Congress of the United States during the presidential term of Abraham Lincoln to provide independent scientific advice to the Congress and people of the United States.

Mac Lane became convinced that one reason the U.S. mathematical community was having difficulty in securing appropriate financial support for research and education was that those who set national policy knew virtually nothing about the nature of mathematics nor its benefits to society. At his instigation, the Conference Board of the Mathematical Sciences (CBMS) - a consortium of a dozen or so different mathematical professional societies - successfully sought support from the National Science Foundation for a project to explore and promote public understanding of mathematics.

At that time, about 1974, there was virtually no coverage of mathematics in newspapers in the United States, nor was there much coverage in general scientific periodicals. Allen Hammond, who had just finished a Ph.D. in applied mathematics (geophysics) at Harvard, had been hired by *Science* magazine a few years earlier to edit the Research News section; he hired Gina Bari Kolata who had master's degrees in biology and in mathematics (and who was the wife and daughter of mathematicians). Between them they produced a few articles a year about mathematics - and that was essentially all there was.

I worked part-time for CBMS for a few years on the NSF project, making contacts and testing the water. We held a meeting at the Ontario Science Center for leaders of science museums; we arranged for a seminar on mathematics at the annual meeting of the Council for the Advancement of Science Writing, a small professional society of science journalists; we discussed ideas for mathematical topics with the producers of NOVA, a television science series produced in England by BBC and in the United States by WGBH in Boston; we fed lots of story ideas and actual draft articles to editors and science writers at the *New York Times*, *Scientific American*, *Science News*, and *Science*; and we produced a prototype mathematical magazine called *Mathematical World* that helped pave the way for Springer-Verlag's *The Mathematical Intelligencer*.

4. CATASTROPHES

One anecdote from this period illustrates the problems we faced. *Science News* is a small but important publication in the United States that produces each week about sixteen pages of research news written in a style that makes it suitable for use by high school and college students and teachers. It has a large circulation among science teachers in school, so is more influential

than the better known AAAS journal *Science* in attracting students to careers in science.

When I was introduced to Kendrick Frazier, editor of *Science News*, he explained that he did not cover mathematics because it was impossible: there were too few stories of interest to their readers, and no one could make even these few stories clear to their audience of students and teachers. He did agree, however, to read some samples that I promised to send as a trial to see if perhaps it could be done.

The first thing I sent him, in September of 1974, was a very short news report from the Vancouver meeting of the International Congress of Mathematicians based on Christopher Zeeman's talk on catastrophe theory. That, I thought, had sufficient appeal to interest even the most jaded editor.

Two things happened in the months that followed. First, *Science News* printed the report and, several months later, a follow-up. It turned out that they received more mail on that story than on any other they ran that year. I received letters from all over the United States, and all over the world, especially from scientists and teachers who wanted additional references and further information. As an existence proof that mathematics can be made interesting, it succeeded.

But then there were the mathematicians. Hirsh Cohen, I remember, expressed concern that this wasn't new mathematics. It was simply a rediscovery or repackaging of some very old ideas about dynamical systems due to Poincaré. There was some evidence that even Laplace and Euler knew of these phenomena. So it was a gross disservice to mathematics to single out catastrophe theory as one of the very few examples that the public would see that year about contemporary mathematical research. The news wasn't really new.

Other mathematicians were not so polite. They excoriated the purveyers and reporters of catastrophe theory for spreading mathematical malpractice by suggesting applications, especially in the social sciences, that could not be sustained by scientific theory. In the physical sciences where there is a potential function that ensures that the mathematical theory paralleled a scientific model, they argued that the catastrophe theory is legitimate but old; in the social and behavioral sciences where there is no obvious potential function, they argued that catastrophe theory is pseudo-science. In either case, the news about catastrophe theory was not fit to print.

The public, of course, did not understand what the argument was all about. They did hear from many sources about this latest trend in mathematics and about some of its more exotic applications. For many, it was their first realization that mathematicians actually do something other than teach. The public began to realize that mathematics, like biology and physics, is an active area of research and that mathematical research, like research in biology and physics, is beyond their comprehension. DNA, quarks, and catastrophes were comparable abstractions in the public mind. They didn't understand any of it, but they did recognize that it represented the frontier of science.

From my point of view, the catastrophe stories were far from a catastrophe for mathematics. Indeed, they served their central purpose very well: to awake a sleeping public to the fact that mathematics is an area of research just as active and potentially just as interesting as any other.

5. DISTORTIONS

The CBMS project eventually produced the volume *Mathematics Today*, which led to its sequel *Mathematics Tomorrow*. My forays into mathematical journalism succeeded well enough that I served as mathematics correspondent of *Science News* for a period of about six years, writing occasional pieces as I found time and opportunity. Fortunately, Ivars Peterson joined *Science News* as a summer intern just about the time that I was getting too busy with other matters to sustain this work. He had a strong background in physics and mathematics and was eager to take over this beat, which he has done with

distinction. Some of you may have seen his recent book *The Mathematical Tourist*, which retells many of the stories that he has written for *Science News* throughout the 1980's.

Before returning to the chronology of events in the United States that has literally transformed the level of press coverage of mathematics, I'd like to discuss a second anecdote that reveals yet another pitfall - distortion. In 1979 I received a tip from someone, probably Ron Graham, about the publication by the Russian mathematician L.G. Khachian of what has since come to be known as the ellipsoid algorithm for solving linear programming problems. On October 6 I wrote an article on this surprising discovery for *Science News*; a month later, Gina Kolata wrote one for *Science*, and shortly thereafter Malcolm Browne wrote a front-page story for *The New York Times*. Each of us engaged in slight journalistic oversights in the interests of clarity - since surely none of the readers could absorb a full mathematical statement of the result. But as the story progressed from mathematically-trained writers to generalists, the border between innocuous simplification and dangerous distortion was crossed by writers and editors who did not know enough mathematics to understand the story.

One can follow the progression of exaggeration in the three headlines: In *Science News*, my story appeared under "Linear Programming: Solid New Algorithm;" in *Science* it became "Mathematicians Amazed by Russian's Discovery;" while the *Times* proclaimed across four columns of the front page, "Soviet Discovery Rocks World of Mathematics." By the time the story got to the *Times* - and also to the *Guardian* in England - it sounded as if the Russians had discovered a secret for solving the travelling salesman problem and cracking secret codes. "This fact has obvious importance for intelligence agencies everywhere," reported the *Times* in ominous language.

This story has certain subtle features. First, in 1979, it was rather well known - even among science journalists - that some important problems were intractable even for the fastest computers. Second, linear programming was a tool of enormous economic significance in the oil industry, in transportation, and in defense. Third, the protagonist in this story was Russian, and the media were in the United States. The story broke just as Ronald Reagan began his campaign for President under an anti-Soviet "evil empire" theme.

The correct mathematical news in this story was that no one knew, prior to Khachian's discovery, whether linear programming did or did not belong to the class of NP-complete problems - the intractable ones. There was no known polynomial-time algorithm, but no proof that none existed. We did know that the simplex method, the mainstay of effective LP algorithms, was not in itself polynomial time for all possible inputs: it was easy to construct examples, albeit quite artificial, for which the simplex method took exponential time to converge.

The ellipsoid (or interior) algorithm was the first algorithm guaranteed to converge in polynomial time for all LP problems, both realistic and artificial. So the mathematical news in this story was a proof that LP was in the class of polynomial time problems - those for which a polynomial time algorithm is known to exist. The new method held promise of improving on the simplex method in some cases, especially in the integer-programming variants which are intrinsically more difficult, but efficiency depended critically on concrete computational details since the interior methods involved a lot of matrix inversions. So actual performance would depend greatly both on the particular problem and on the efficiency of the particular computer code. (As it turned out, some years later Narendra Karmarkar at Bell Labs discovered a new approach using the distortions of projective geometry to produce a truly efficient interior algorithm for linear programming. But this gets ahead of the story as it unfolded in 1979.)

The distinction between the general theorem (for the first time, LP was known to be not intractable) and the particular case (although polynomial-time, the ellipsoid algorithm might compute more slowly than the exponential-time simplex method because of details of input data and coding algorithms) was generally too fine for science journalists (or their readers) to catch. My

story was accurate, albeit just barely. Berkeley computer scientist Eugene Lawler, in an analysis of this episode in *The Sciences* (September 1980) said of my report that it was "generally correct, and did not seriously mis-state the significance of the achievement." Gina Kolata's report had one unfortunate sentence claiming that Khachian's result is "tied to" the infamous travelling salesman problem (which, of course, is tied to encryption algorithms). Malcolm Browne in the *Times* - the third in the series - interpreted that link as a solution, and then set off speculation about the Russians beating the U.S. to a key computer code for industrial competitiveness.

I need not describe the backlash that these stories caused in the U.S. mathematical community. After being inundated with letters and briefings by mathematicians, the *Times* eventually printed what it considered to be a correction, saying that further analysis by American mathematicians revealed the result to be '"far from the seminal achievement originally portrayed." They coyly refrained from mentioning who it was - mathematician or journalist – who painted the original portrait.

Despite the errors and distortions, I would not be the first to criticize Browne or the *Times*. Ultimately, the public doesn't remember the details, whether right or wrong. They *do* remember, however, that mathematics has something to do with industrial efficiency, that computer codes are things that mathematicians work on, and that competition in these areas is an important part of the East-West political game. So again, the long-term goal of portraying mathematics as an active, interesting field of significance to society is achieved. Who cares if the algorithm is as bad as n^6 ?

6. COMMITMENT TO ACTION

Many of the stories that found their way into the U.S. press during the 1970's and early 1980's were due to tips from one person: Ronald Graham. Graham went to a lot of meetings, he knew the few journalists and mathematicians who were writing general stories, and he believed in the importance of this activity. Without his consistent tips, the $\in$ coverage of this period would have been only $\in/5$.

Of course the price of tips from Ron Graham was a view of mathematics from the perspective of discrete mathematics. Algorithms and number theory thrived in the press; non-linear analysis and geometry did not do as well. But again, that's not so bad, since most of what emerged in the news was not just a sample of new mathematics, but a sample drawn from new areas of mathematics. So the alert public who followed these stories - mostly scientists, by the way - got the message that mathematics was not only thriving, but expanding into areas untouched by their school experience. That's not a bad message to receive, however slighted it may make the PDE folks feel.

It soon became clear to leaders of the mathematical community that they could not rely on the press to provide the level of coverage needed to turn around what was becoming a critical situation in the United States for mathematics research and mathematics education. The press does not serve any external community. In theory, it serves the public interest; often it serves only its own interests. But never does it serve mathematicians' interests. If mathematicians wanted more coverage, they would have to do something about it by themselves.

The Joint Policy Board for Mathematics - a joint action committee of the three major university-level mathematical societies in the United States (AMS, MAA, SIAM) - established a small committee consisting of Ron Graham, Joe Keller and me to make recommendations. Our chief recommendation was that the mathematical community needed to do what every other scientific community had done: establish an office of external relations that included a professional who knew how to deal with the media.

There were two thrusts to this message. First, the mathematical community must do this together, since it would make no sense to splinter efforts among various groups, each with its own private agenda. Second, the lead person should not be a mathematician, but a professional experienced with print and video media. Mathematicians have little expertise in promoting stories to the media, and the few examples we had showed that they were incapable of learning.

I cite as an example the American Mathematical Society which, year in and year out, sent press releases to journalists about major speakers at its national meetings. These communications, in fine eight-point single spaced print (rather than editable twelve-point double spaced type) consisted of a concise abstract of the talk, a list of the speaker's previous publications, and a mathematical biography - all in language that only a specialist in the speaker's field could understand.

It is not surprising that no journalists every chose to come to AMS meetings on the basis of these types of releases. What might be a surprise is that no one with authority in the Society recognized the futility of this approach. Many observers of mathematicians claim that even this is not really a surprise - that mathematicians as a group are constitutionally indisposed to understand what motivates ordinary people.

The recommendation of our Committee was accepted by the societies, and gradually implemented. Kathleen Holmay, a public relations consultant who specializes in science issues, was hired in 1985 under part-time contract for the Joint Policy Board for Mathematics. It was a fortuitous time, for it came right on the heels of two major documents that focussed U.S. attention on mathematics and mathematics education.

In 1983 a report *A Nation at Risk* awoke the American public to serious and seemingly irreversible problems in our educational system. In 1984 the National Academy of Sciences released *Renewing U.S. Mathematics: Critical Resource for the Future*, what we all call the "David Report" after its committee chairman Edward E. David, former Science Advisor to President Nixon. The first report called for major overhaul of the nation's educational system, the second for major increase in support for mathematical research.

These two themes provided the spark needed to mount an effective public information campaign. They gave Kathleen Holmay an agenda that resonated with interests of the public: mathematics education, and international competitiveness rooted in mathematical sciences. By persistent and clever campaigns, she has managed to entice dozens of reporters to take on mathematics as one of their beats. In the last five years, press coverage of mathematics and mathematics education in the United States has increased by at least an order of magnitude.

7. CONSEQUENCES

Let no one think that this increase was due to a compelling public or reportorial interest in mathematics. Reader interest still runs to issues that affect lives such as cancer, global warming, or AIDS; journalists still view mathematicians with suspicion and latent hostility from their own school and college experiences. That's a risk we will always run: everyone who is not a mathematician probably stopped studying mathematics as the result of a particularly unpleasant experience in school. No other subject has such a legacy of negativism to overcome.

What success U.S. mathematicians have had in publicizing mathematics is the result of two things: a competent professional in place to make the news flow, and an orchestrated climate of crisis to make the media receptive to the news. Reporters will not be able to convince their editors to make space for mathematics in competition with news about potential cures for AIDS unless we give them substantial, documented reasons why mathematics is just as important.

We have a saying that expresses well just what's going on - at least if we read it backwards. The saying is: "No news is good news." In mathematical journalism, the reverse is true: "Good news is no news."

Some of the crisis talk is hype, but much is not. U.S. standings in international comparisons of mathematics education are dismal. Our ranking among nations is like our balance of payments: below all our competitors, and just barely above some third world countries. During the 1970's, the number of college graduates with mathematics majors fell by over 50%, as did the number of U.S. students who continue on to a Ph.D. in mathematics. The U.S. National Security Agency - the formerly super-secret enterprise that deals with encryption of military secrets - has been trying to hire almost as many mathematicians as we produce each year, but without success.

The good side of these dreary figures is that it is driving salaries for mathematicians up, at least in institutions with sufficient resources to compete for the best people. And it is opening the pages of the popular press to stories about mathematics. The wedge that creates the opening is mathematics education, since everyone with children in school has opinions about education. From there, reporters can move naturally into how computation is changing the nature of mathematics, and then into stories about news in mathematics.

Overall there has been an increase from 2-3 to 16-20 in the number of reporters in the United States who take seriously news in mathematics, and an increase from under twenty to several hundred in the number of stories about mathematics and mathematics education that appear annually in magazines and newspapers addressed to general audiences. Much of this success has been built on a series of events created or orchestrated by the mathematical community:

1986 The Congress of the United States and President Reagan declare Mathematics Awareness Week in the month of April.

1988 The Centennial of the American Mathematical Society provides an excuse for a year-long, one-event-per-month focus on mathematics research.

1989 Publication of *Everybody Counts* and *Curriculum and Evaluation Standards for School Mathematics* provides a reason to focus on issues in mathematics education.

8. CONTROVERSY

As one might expect, publicity about mathematics has not been achieved without controversy. The lines that Ms. Holmay casts to journalists new to this field sometimes snare mathematicians who recoil in disgust at the worm they find on the end of the hook.

At the International Congress of Mathematicians in Berkeley in 1986, a press release opened with appealing comments about numbers, statistics and the consumer price index as an inducement to attend a special pre-Congress talk on modular forms. For the Centennial of the American Mathematical Society, which opened on the eighth day of August, the eighth month, in 1988, the press office put out a clever piece by Martin Gardner on "Dr. Matrix and the Wonders of 8," a spoof on numerology that many reporters thought was serious. But they bought it, as we say, "hook, line and sinker." On the local television news there was a feature story whose lead was, as one might expect, "8/8/88 - the things mathematicians do for a living." Without such a lead, mathematics may never have made the news at all.

Ms. Holmay works directly under Kenneth Hoffman, who served for five years as Director of the Office of Government and Public Affairs of the Joint Policy Board. Together they orchestrate the now-annual Mathematics Awareness week using press releases, posters, postcards, school activities, and whatever promotional events they can dream up. Each mathematics awareness week has a special theme, backed up by a poster that teachers can hang on bulletin boards. This year's theme was "Discovering Patterns;" it features information from Branko Grunbaum based on his book *Tilings and Patterns*, an article that I wrote for *Science* entitled "The Science of Patterns," and special material written by Ian Stewart on "The Impact of Mathematics." (Despite 200 years of independence, Americans must still turn to England for an occasional infusion of our mother tongue.)

The effort of the last decade is paying off. Hoffman and Holmay serve as a semi-permeable membrane separating the arcane world of mathematics from the homely world of journalism. They develop themes and invent story lines that resonate with both public interest and mathematical events; they introduce journalists to mathematicians and mathematics educators, and provide essential background information to journalists who know nothing about the world of mathematics. They also fend off attacks from mathematicians insensed over numerology, and parry thrusts by journalists who want to limit school mathematics to consumer topics. Within the world of mathematics, they make news of what's new.

9. LESSONS

One can read these events in many ways. By the standards of other sciences, popularization of mathematics is still an insignificant fraction of total science journalism in the United States. But by the standards of the early 1970's, today's public knows vastly more about the importance of mathematics in school and the role played by mathematics in society. So we have made much progress, yet there is still a long way to go. As we move along this largely unblazed trail of popularization of mathematics, I commend to you several lessons from our experience in the United States:

1. *Mathematicians make lousy publicists.* If you want the job done, hire a professional. Mathematicians who serve as publicists are always shadowed by their colleagues' standards. Despite inevitable distortion, non-mathematicians will almost always do a better job of actually communicating with the public.

2. *Theorems won't sell in a vacuum.* If you want to interest the public in real mathematics, first get their attention with something closer to their heart - like education, economy, or environment.

3. *Literal truth is irrelevant.* The purpose of popularization is to raise awareness, not to educate. What must be communicated is not the letter but the spirit of mathematics. The criteria of success is not an increase in knowledge, but a change in attitudes.

4. *Don't underestimate public interest in mathematics.* Everyone has studied some mathematics; many are amateur mathematicians, some even closet amateurs. There is more public interest in mathematics than editors realize or admit.

5. *Don't underestimate public ignorance of mathematics.* Most people don't even know that mathematics is a living discipline. Their image of the subject is locked in the age of Euclid or Newton, framed by school experience of set problems and mechanical worksheets. Changing this image is a sufficient and worthy goal of any program to popularize mathematics.

6. *Don't pander to utilitarianism.* Editors and reporters often judge news by immediate utility. While utility is a legitimate value of mathematics, immediate utility is not. Don't be drawn into dishonest claims of cures for cancer or economic miracles as the consequence of the latest breakthrough in mathematics.

7. *News need not be new.* Rarely do important trends become visible overnight. The impact of computing on statistics and on non-linear analysis has been gradual, not sudden, but is no less news for that reason.

8. *Connect with school mathematics.* School is part of everyone's experience, for good or ill, so it provides a common base of discourse. New mathematics inevitably suggests possible new ideas for school curricula, which can serve as a news peg for journalists.

9. *Highlight legitimate applications.* Applications appeal to multiple journalistic beats - to science or health or economics. Good mathematics shines through good applications.

10. *Stage news-worthy events.* Since reporters need an "event" to claim scarce space in the press of daily events, meetings should be planned to provide reporters with a legitimate news peg.